THURSDAY, SEPTEMBER 3, 1891.

THE REPORT OF THE BOARD OF TRADE COMMITTEE ON ELECTRICAL STANDARDS.

TARDILY, and in a somewhat piecemeal if not grudging fashion, some small provision has been made by Her Majesty's Government for the regulation, under the Board of Trade, of the new but vigorous and rapidly-extending industry which recent developments of electrical science have brought into existence. In no previously-existing branch of trade has the problem of settling standards of measurement been so difficult of solution, and in no other has the problem been so completely solved without trouble, expense, or intervention on the part of the Government itself. For the last twenty-five or thirty years a Committee of the British Association has laboured at the gigantic task of building up a system of units, which involved as a mere preliminary the revision of the conceptions and units of dynamics in order that these might form a basis for the definition of units for the far more complex physical quantities concerned in electricity and magnetism, quantities many of which had previously been by no means clearly apprehended, and which then received for the first time precise statement and definition.

Much of the work of the British Association Committee has been thankless, tedious, and, from its very nature, of a kind fitted to excite the cheap scorn of the self-styled "practical man," but it has made applied electricity possible, and has reacted in no slight degree on the progress of theory itself. The problem of the determination of the ohm—in other words, the process of realizing a standard of resistance according to the theoretical definition—has suggested problems to the theorist in the solution of which the theoretical investigator has been led to both direct and side-results of the very greatest value to the progress of science, and, in an unexpected manner, to the facilitation of practical applications. In no science have theory and practice been so closely connected during the last quarter of a century, and in none has the union been so markedly productive of good. By far the most interesting chapters of the history of electricity during the nineteenth century will be those that refer to its last three decades; may they chronicle a still closer alliance of the engineer and the experimenter, the electrical man of action and the mathematician. Here union is strength and dominion over the forces of Nature; disunion is waste of energy and slow progress in all that relates to the material, and therefore also to the social, advancement of the human race by means of electrical invention.

The establishment of the nucleus of an electrical standardizing laboratory in London, and the appointment towards the end of last year of a Committee to decide upon and recommend for adoption electrical standards for use in trade, testify to the great importance which the electrical industries have attained in this country in spite of the mistakes which attended their inception, and the general discouragement and disfavour with which they were received by the various interests they threatened.

The proceedings and report of the Committee have just been published in a blue-book, which contains matter of great interest to all engaged in electrical work. The vista which it opens up as regards the future operations of the standardizing laboratory may well dismay Her Majesty's Government; although no doubt due provision will ultimately be made for all its work. But of this at another time; at present we wish to direct attention to the resolutions of the Committee, which will be found in another page.

In the first place the Committee signify their adherence to the units of length, mass, and time as fundamental units, and adopt the C.G.S. system. This was only to be expected, for, after all, though some people may think that a better system could be devised if the work had to be done afresh, and they had a share in it, still collectively the body of scientific opinion is distinctly conservative, and there is little danger that any ill-advised attempt to disarrange the accepted system of theoretical and practical units will succeed.

Their third resolution, that the standard of electrical resistance should be called the ohm and should have the value 1,000,000,000 in terms of the centimetre and second in the ordinary electromagnetic system, is of great importance. It seems to settle once for all the question which has been debated over and over again, whether after a standard ohm has been realized, it will, like the standard yard or metre, be ever after the standard; or whether, if in case of variations in the physical properties of the substance, it shows an unexpectedly large divergence from the definition, a new standard ought to be constructed. Those who have assumed the former alternative have forgotten that the ohm is a derived unit, depending on the already fixed units of length, mass, and time, and that, therefore, its derivation ought to be as exact as the ever-widening resources of science can make it. For practical purposes of trade the standard fixed upon now and its copies are likely to remain undisturbed for a long time, and will probably only be corrected if there is serious alteration with time in their resistances. But the ohm will still be defined as 10^9 C.G.S. in the ordinary electromagnetic system of measurement, in which the magnetic permeability of air is assumed to be unity.

The fourth and fifth resolutions provide the definition of a practical realized ohm (1) by means of a column of mercury, (2) by comparison with the British Association unit, which it is stated may be taken as ·9866 of the ohm.

The wording of Resolution 4 strikes one as curious. The mercury column is to have a "constant cross-sectional area of 1 square millimetre." If "constant" has its ordinary sense of invariableness with time, the specification of 1 square millimetre renders it unnecessary. It has here apparently the usual sense of "uniform," that is, the section is the same at every part of the tube.

We are glad to see that the length adopted for the tube is 106·3 centimetres, instead of 106 centimetres, the round number adopted at the Paris Conference, and proposed, by the British Association Committee in 1886, to be legalized for a period of ten years. All the latest and best determinations of the ohm point to 106·3 as a convenient number very closely agreeing with the true value, and its adoption now is probably only an anticipation of the decision which will be arrived at in a few years when the resolutions of that Conference are reconsidered.

In the adoption of a metallic working standard (announced in Resolution 5) the Committee only endorse an opinion long ago expressed by working electricians, that the mercury standards constructed in straight or spiral glass tubes are not practical instruments; they are difficult to handle, liable to breakage, and the only argument for their retention, the possible variability of metallic standards, has been shown to be almost baseless by the results of the continued and careful observation of the various metallic resistance coils deposited at Cambridge.

Passing over the resolutions which provide for copies, and multiples and submultiples of the ohm, with the remark that the long-felt want of trustworthy standards of low resistance will now at last be supplied, we come to the definition of the unit of current. Here again a theoretical definition corresponding to that of the ohm is given first; then for practical purposes it is stated "that an unvarying current which, when passed through a solution of nitrate of silver in water, in accordance with the specification attached to this report, deposits silver at the rate of 0·001118 of a gramme per second, may be taken as a current of 1 ampere." This is the most reasonable course that could have been adopted. The specification is practically one of the procedure adopted by Lord Rayleigh in his experiments on the electro-chemical equivalent of silver, and as Lord Rayleigh's absolute result was to be made the practical standard, it was right to recommend the same mode of experimenting.

Resolution 11, which defines the ampere in the case of an alternating current, was the subject of a good deal of discussion, and of some adverse comment by one of the witnesses examined on behalf of the electrical trades. The resolution states "that an alternating current of 1 ampere shall mean a current such that the square root of the time-average of the square of its strength at each instant in amperes is unity." It was pointed out by the witness referred to, and by at least one member of the Committee, that this was giving a very special meaning to the term, one, moreover, inconsistent with the obvious definition, that of the simple time-average of the current. This latter average would, in the case of most periodic machines, be simply zero, unless the currents in the alternate half-periods were commutated so as to agree in sign with those in the other halves. But in the case of such a machine as the Brush, used for lighting incandescent lamps, the definition given in the resolution would have to be used; whereas if the machine were used for electro-plating, the simple time-average would have to be employed. This would give for the same current passing through the machine, from instant to instant, two different average values. The electric lighting application of periodic machines is, however, by far the most important, and the Committee did well, perhaps, to retain what is already the generally understood sense of the word *ampere* in connection with alternating currents. It ought to be, however, clearly understood that the main application of the definition will be to the measurements of currents in electric lighting, and that generally in other cases another definition will have to be employed.

Another important discussion took place over the definition of the standard unit of "pressure." In the first place, we should like to say here that we object entirely to the use of the term "pressure" in this connection. It has come as a sort of analogue of hydraulic pressure, and it has certainly led to very erroneous notions in the minds of the general public as to the functions of electric supply-mains, and also as to electricity itself. It is a pity that so many of the present pioneers of electricity, who are also leaders of physical science, should have countenanced by their example this misuse of a scientific term. We all know how strenuously some of these gentlemen have objected to the term "tension" as in "high-tension electricity"; surely "high-pressure instruments" and "electricity supplied at high pressure" are as objectionable, if not even more misleading. The use of the term *voltage*, or some such word, in the present Report, would have avoided the endorsement which it seems to give to what we think is a most unfortunate name for a physical quantity which is not a pressure at all; and it is to be hoped that the British Association Committee (who, by the way, were represented on the Committee of the Board of Trade) may be able to prevent this phrase from being added to the many other, though generally less objectionable terms which infest the literature of electricity.

A discussion arose as to whether the definition of the volt as the "pressure which, if steadily applied to a conductor whose resistance is one ohm, will produce a current of one ampere," was sufficiently definite. There might, it was argued, be an internal electromotive force in the conductor, and the "pressure" applied to the conductor might be regarded as that applied from the outside, or actually existent between its terminals, as shown by an electrometer. For example, the conductor might be the armature of a dynamo; the difference of potential might be considerable and the resistance only a small fraction of an ohm. In such a case it is, of course, well known that the electromotive force producing the current through any part of the armature resistance, according to Ohm's law, is the total internal electromotive force of that part, *minus* the difference of potential existing between its terminals (both being taken positive), and it is the difference thus obtained that is to be regarded as the applied "pressure" of the definition. In the same way in a voltameter, the electromotive force causing the current, according to Ohm's law, would be the existent or applied difference of potential, *minus* the internal back electromotive force developed by the chemical action. There were other difficulties about the specification of the ends of the conductor and the canalization of the current, and it was therefore thought desirable to adhere to the simple form of definition given in the report. It must be admitted that the definition leaves room for legal disputes in practice, and we think that it would have been perhaps better to have introduced on these points some kind of note or specification referred to in the resolution, so as to be taken along with it in the event of any dispute about the meaning of the definition.

A further question arose as to the provision of a practical standard of electromotive force in the form of a constant cell; and it was decided, partly in deference to the expressed wish of practical electricians, that the Clark cell should be adopted for this purpose. Its electromotive force, within certain limits of error to be determined by a sub-committee appointed for the purpose of preparing a specification for the construction and use of the cell, is stated to be 1·433 volts at the temperature 62° F. By means of this cell and known resistances, it will be possible to calibrate instruments without the use of electrolysis, and this to many persons would be the readiest and most easily carried out method. Of course, logically speaking, the standard of electromotive force is settled when those of resistance and current are fixed, and thus, if the order of definition is adhered to, the cell does not come in. But its electromotive force having been determined by careful measurement, and found to be so constant as it is, and so consistently the same in different specimens when the mode of construction is carefully attended to, it is too valuable a standard of reference to be set aside.

A very interesting discussion took place as to the mode of preparing these cells, and on the experience of different investigators as to their behaviour. Some of the divergences stated in the discussion were probably due to the different degrees of manipulative skill possessed by the various observers. A few careful experiments with different batches of cells carried out personally by the members of the committee interested in the matter would set the question at rest, and probably entirely confirm Lord Rayleigh's marvellously consistent results.

A side-point which came out in discussion is worthy of notice. We have not in this country any legal definition of temperature, whether Centigrade or Fahrenheit. In the definition of the standard yard 62° Fahrenheit is specified, but there is nothing to tell how that temperature is to be determined. It is well known (though apparently not to some of the text-book writers on heat) that mercurial thermometers, made with different kinds of glass, while agreeing at the freezing and boiling points, agree nowhere else, and all differ more or less from the air-thermometer. In very accurate work these discrepancies become very important, and thermometers must be calibrated by means of standards, if their indications are to be of any use for comparison. Some legal definition of temperature will, ere long, have to be given, and it seems rather a pity that the Committee did not practically settle this by saying what they meant by 62° Fahrenheit.

The definition of the volt for alternating currents, embodied in Resolution 15, is, of course, a mere consequence of Resolution 11, and these two definitions taken together are specially applicable to the measurement of the power spent in lighting incandescent lamps.

We have only to note that the Committee, in Resolutions 12 and 16, adopted instruments on the principle of the balance for the measurement of currents, and on the principle of Sir William Thomson's quadrant electrometer, used idiostatically, for the measurement of differences of potential—except for large differences, when an electrometer on the principle of the balance is to be employed. Thus the beautiful electrometers invented long ago by Sir William Thomson are likely to become at last, in a modified form, Board of Trade standards of exact measurement in industrial electricity. This is by no means the only striking example which could be cited of the thoroughly practical, because thoroughly theoretical, character of the instruments invented by one who understands all sides of the difficult problem involved in the invention and construction of scientific apparatus.

No resolutions were framed by the Committee on the very important subject of the measurement of power and energy. This must, however, come to the front before very long, and will tax the resources of the standardizing laboratory and its officials, assisted, as no doubt they will be, by Committees such as this which has just reported. We congratulate the Committee on the results of its labours, and trust that the requisite Order in Council will be passed before long confirming its resolutions. The laboratory will then be able to get to work, the necessary standards which have been asked for so long will be made accessible to those engaged in the electrical industries, and some serious difficulties under which they have laboured, in supplying electric light and power to the public, will be at last removed.

THE CONGRESS OF HYGIENE.

We print to-day a report of the important discussion in Section II. (Bacteriology) of the Congress of Hygiene, on "Immunity, Natural and Acquired":—

Dr. Roux, of the Institut Pasteur, in an introductory address, indicated the scope of the discussion. He began by saying that, in inviting a pupil of M. Pasteur to open the discussion on this subject, the Organizing Committee had reminded the Section that the great amount of interesting work which had recently been done on the subject had one point in common—namely, the attenuation of virus, and preventive inoculation, the two subjects with which M. Pasteur's name would for all time be honourably associated. With the single notable exception of vaccination, the only way of conferring immunity against any disease was the inoculation of the virus of the disease. To the old dangerous method of producing immunity by inoculation, Pasteur had added the less dangerous one of preventive inoculation by means of an attenuated virus, to which he had applied the term vaccination. The designation "attenuated" virus ought to be reserved for virus weakened without being attenuated—for example, by artificially lowering the vitality of the organisms for producing it.

Methods of Attenuation.—Two methods of attenuation had been described by M. Pasteur—namely, the prolonged exposure of a culture to air at a suitable temperature, and the passage of the micro-organisms through the bodies of different species of animals. Other methods had also been employed—for example, the action of heat, the use of antiseptics, of compressed oxygen and light.

In all cases, whatever the method employed, it was found to be necessary that the attenuation should be effected slowly and gradually; rapid attenuation rendered a virus altogether inactive without impressing on it any hereditary weakness. In whatever way the virus was prepared, it must, in order to confer immunity, be brought into direct contact with the tissues of the animal. In the early experiments the virus employed was always living; the living microbe, itself attenuated as to its virulence, was used. Another possible method of conferring immunity was the inoculation of the chemical substances produced by the micro-organisms.

Phagocytosis.—Dr. Roux next dealt with the doctrine of phagocytosis associated with the name of Dr. Metchnikoff. This observer had proved, by the study of the amœboid movement of certain cells that they possessed the power of including other cells and bodies in their substance. The phagocyte cells originated in the mesoderm. They possessed, further, the property of being able to digest the bodies which they had ingested. They were, in fact, the only cells which manifested in the human body any intracellular digestion. If the history of a bacterium in the interior of a phagocyte were followed, it would be seen that it underwent a peculiar series of alterations, very different from what took place when a microbe died in cultivating fluids. Whether a virulent virus was introduced into the bodies of animals which resisted inoculation, or whether attenuated microbes were injected